

The Ordovician–Silurian boundary in the Algerian Sahara

P. Legrand

Directeur Laboratoires Exploration (Groupe) TOTAL, 218–228 Ave du Haut-Lévêque, 33605 PESSAC Cédex, France.

Synopsis

Two sections, at eastern Tassili-n-Ajjer and at El Kseib, demonstrate the Ordovician–Silurian boundary, with graptolites at intervals and rare shells, however the *acuminatus* Zone itself is not recorded. The sections are internationally important firstly in demonstrating excellent glacial and periglacial sediments during the late Ashgill, and secondly in showing that this continental ice-mass melted and was succeeded by, but was not the origin of, the transgression during the latest Ordovician, in *persculptus* Zone times.

Introduction

Because of the uplift that probably affected most of the Algerian Sahara near the end of the Ordovician, and the circumpolar conditions which caused the development of a continental ice sheet (Debyser *et al.* 1965), the Algerian Sahara seemed originally an unlikely country for biostratigraphical study of the Ordovician–Silurian boundary. However, detailed observations from the boundary beds enable us to show clearly an almost continuous succession from the Ordovician to the Silurian in the eastern Tassili-n-Ajjer, whereas to the west, in the Ougarta range, there is a probable hiatus. Moreover, these observations suggest some interesting conclusions about the palaeogeography because this is a country where the glacial events are particularly striking (Fig. 1).

Eastern Tassili-n-Ajjer sections of the Djanet–In Djerane Oued tray and of the In Djerane Oued

Kilian (1928) drew attention to this area by pointing out the presence of a fauna of lowermost Llandovery age. Unhappily, this discovery was forgotten and it was many years later when interest was aroused again following a preliminary collection by the 'Mission sédimentologique sur la couverture sédimentaire du Boudin saharien' in 1965. Two further studies were carried out in the field (1978, 1982) despite substantial logistical difficulties; but only some of the successive results have been published, others are in press.

The stratigraphical succession is as follows (Fig. 2):

Above the Gara Tembi sandstones with a glacial relief:

- (a) the Arrkine argillaceous sandy formation (about 90 m) in which a new fauna with *Climacograptus* (*Climacograptus*) *gelidus* nov. sp., *C. (Climacograptus) arrikini* nov. sp. and *C. (Climacograptus) normalis ajjeri* Legrand occurs near the base.
- (b) The shaley formation of Oued In Djerane in which the following distinctions can be made:
Lower member (80 m) of silty claystones and siltstones with a few carbonate levels; the fauna is as follows: *C. (Climacograptus) normalis ajjeri* Legrand, *C. (Climacograptus) pseudo-venustus* Legrand, *C. (Climacograptus) pretilokensis* nov. sp., *C. (Climacograptus) tilokensis* Legrand and *Zygospiraella* sp.

Middle member (about 110 m) with: a lower submember of shales with *C. (Climacograptus) normalis ajjeri* Legrand, *Diplograptus* (?) *kiliani* Legrand; an upper submember of siltstones and silty shales with *C. (Climacograptus) freuloni* nov. sp., *C. (Climacograptus?) incommodus* nov. sp., and *Glyptograptus* (*Glyptograptus*) *sahariensis* nov. sp. and near the top *C. (Climacograptus) imperfectus* Legrand, and ?*G. (Glyptograptus) aff. persculptus* (Salter).

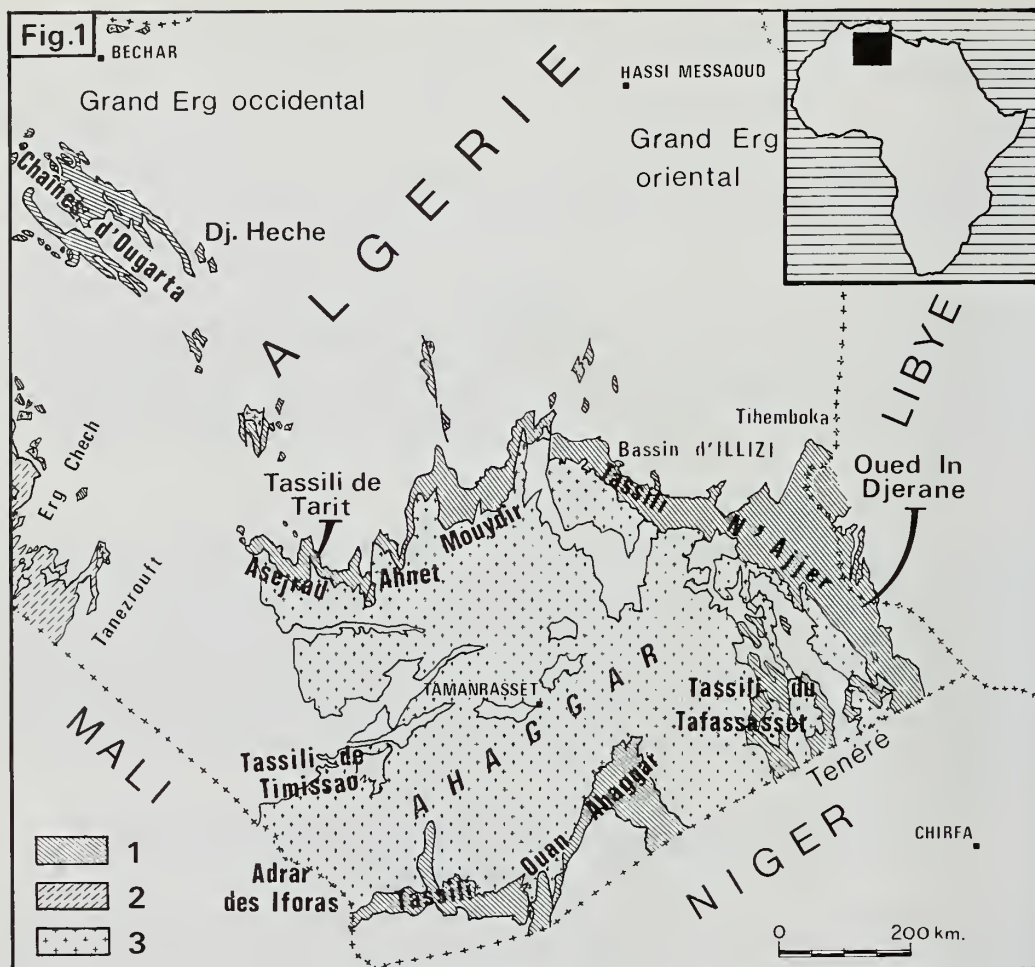


Fig. 1 Outcrops of lower Palaeozoic in Algeria apart from the Intermediate Series (1); Intermediate Series and Cambro-Ordovician of the syncline of Taoudeni (2); and Precambrian and Intermediate Series (3).

Upper member of sandstones with argillaceous silty intercalations. Fossils are only found near the base and include *Diplograptus africanus* Legrand, and *G. (Glyptograptus) tariti* Legrand and then, above, *Diplograptus fezzanensis* Desio.

A lower Llandovery age was originally suggested for the whole Oued In Djerane Formation (Legrand 1976, 1981, 1985a); then an Ordovician–Silurian boundary level at the top of the *Diplograptus (?) kiliani* Zone was proposed (Legrand 1985b, 1986), but a further possibility, of a boundary at the top of the Middle member, must be considered. The arguments in favour of this last possibility are as follows:

- (i) A new subspecies very near to *Diplograptus (?) kiliani* is known in the Kurama Range, Usbekistan (but not in Kazakhstan) and it occurs, according to T. N. Koren, not below the *Parakidograptus acuminatus* Zone, as formerly believed, but below some beds where *C. (Climacograptus?) extraordinarius* or *G. (Glyptograptus) persculptus* was collected.
- (ii) On the other hand, *C. (Climacograptus) incommodus* has some affinities with *C. (Climacograptus) extraordinarius* and in this respect the position of *Zygospiraella*, a genus

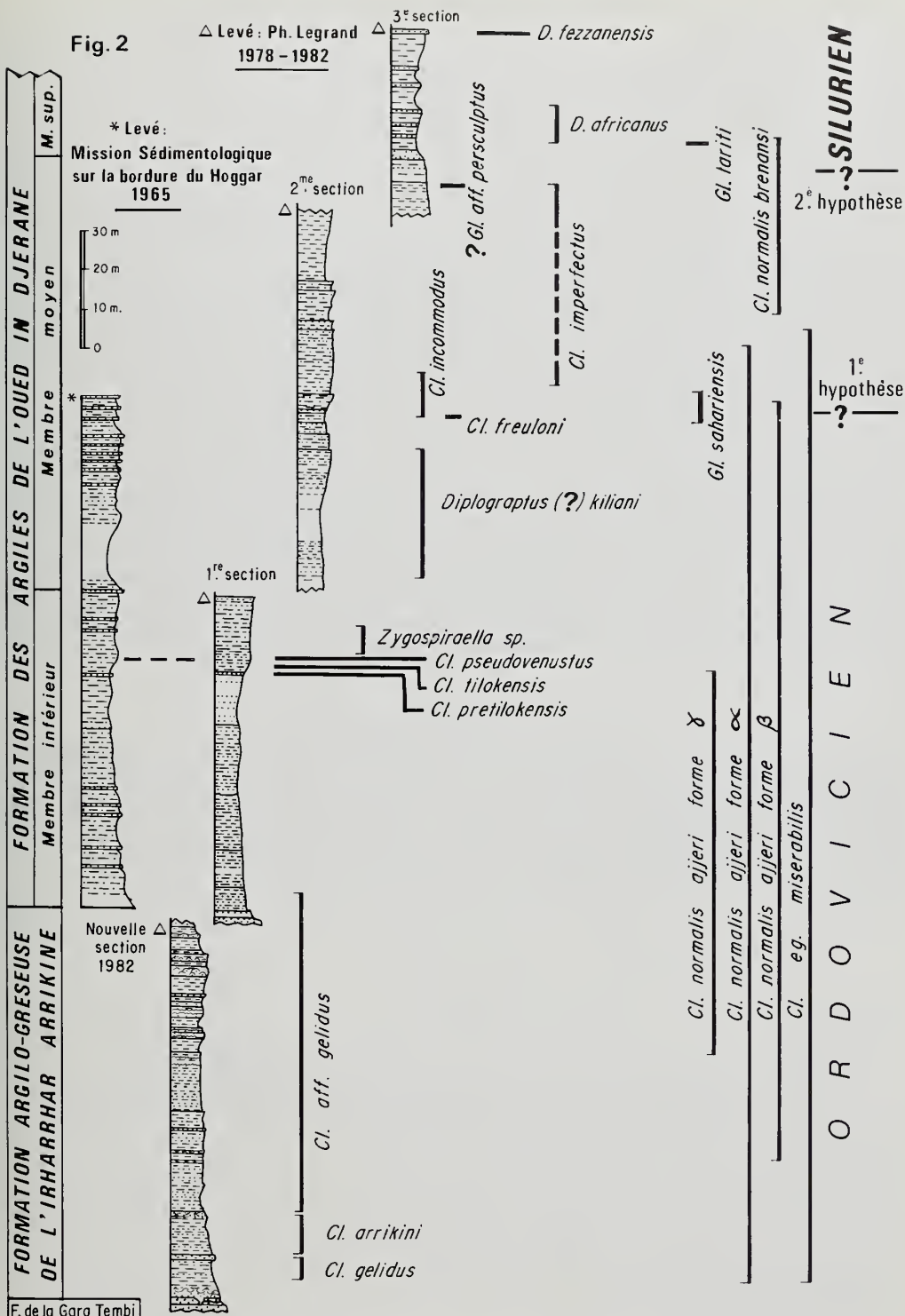


Fig. 2 Distribution of the principal faunas in the sections of the Djanet-In Djerane Oued tray and the In Djerane Oued, Algeria.

only so far definitely recorded from the Silurian, would be the same as that in Kazakhstan (Oysu River section).

- (iii) Finally, rare specimens of ?*G. (Glyptograptus)* aff. *persculptus* have been gathered just below the top of the middle member of the Oued In Djerane Formation.

The objections to the hypothesis are the following:

- (i) *G. (Glyptograptus) sahariensis* is very close to *G. (Glyptograptus) tariti* and has the aspect of a Silurian *Glyptograptus*.
- (ii) *Diplograptus africanus* seems to belong to the *Coronograptus cyphus* Zone (Legrand 1976), and consequently there is a very small thickness for the *Parakidograptus acuminatus* Zone and the *Cystograptus vesiculosus* Zone. The sandstones that form the top of the middle member may be thought to be the equivalent of the zone.
- (iii) *Parakidograptus acuminatus* has not yet been found; one can think of the sandstones that form the top of the middle member as the equivalent of the biozone characterized by this species. However, nor has it been found near the Libyan boundary, where the shales take the place of the sandstones owing to the later transgression there, and where the sedimentation seems to have been more continuous.
- (iv) Perhaps in this apparently very confined area the vertical range of species may not have been absolutely the same as in less restricted regions.

To conclude, two hypotheses can be proposed for the position of the Ordovician–Silurian boundary, but the highest seems the most likely. Moreover, there is no characteristic fauna of the Ordovician in the lower part of the section and this sets problems of correlation with the standard sections (Dob's Linn, Kolyma River, Yangtse Valley), and consequently this section in Algeria can only be a local reference. On the other hand, it has important palaeogeographical significance since it shows the beginning of the transgression onto the southeastern part of the Saharan shield before the end of the Ordovician, which must have involved the melting of the continental ice sheet, at least locally, before the beginning of the Silurian (Legrand 1985).

Ougarta Range–El Kseib section

In the Ougarta Range, the stratigraphical succession of the upper part of the Ordovician includes the argillaceous sandy Bou M'haoud Formation, which is overlain by the argillaceous sandy Jebel Serraf Formation. A mappable unconformity separates these two formations (Arbey 1962; Gomes Silva *et al.* 1963; BRP *et al.* 1964; Legrand 1974). In the eponymous locality, where that formation seems the most complete, the upper part of the Bou M'haoud

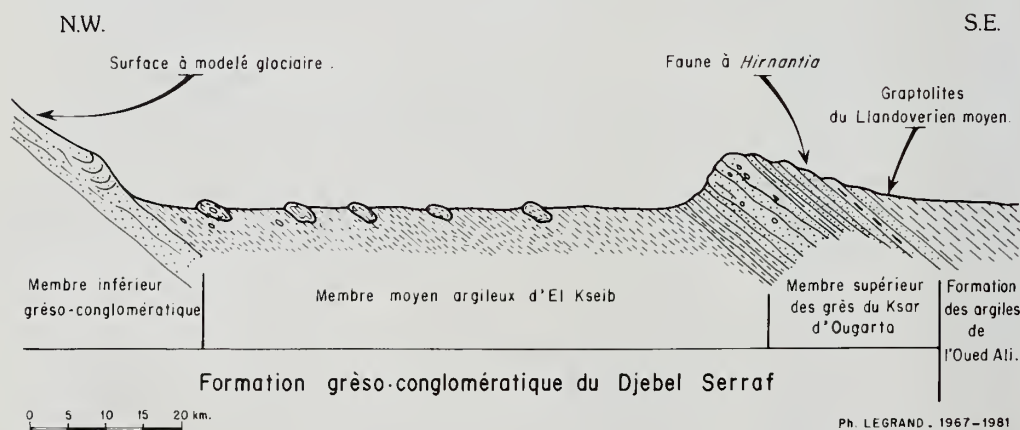


Fig. 3 Section in the vicinity of the Ordovician–Silurian boundary at El Kseib, Ougarta range, Algeria.

Formation is apparently of Lower Caradoc age, with *Klouceki* (*Klouceki*?) nov. sp., *Calymenella* sp., *Drabovinella grandis* Mergl, and *Drabovia* sp.

At first this fauna was attributed to the Upper Caradoc and the beds from which it was collected were considered to belong to the lower member of the formation subjacent to the Jebel Serraf Formation. Going to the north west (in the Daoura), the succession is apparently complete up to the lower Ashgill. Above this the Jebel Serraf Formation appears to be absent or very thin in Bou M'haoud village, with siltstones and sandstones (channel deposits), but no fossils have been found. The quality of the outcrops does not allow us to see the contact with the lowest Silurian shales. Thus, it is near Ougarta that the Ordovician–Silurian boundary must be investigated.

In the classical El Kseib section discovered by Menchikoff (1930), the Bou M'haoud Formation is reduced to its lower member. Above, the Jebel Serraf Formation consists of a well-developed sandy, conglomeratic lower member, then the microconglomeratic shales of El Kseib that prove a periglacial environment; and above these, the sandstones of the 'Ksar d'Ougarta', It is at Ougarta that some brachiopods were gathered from this member by Poueyto (1950). Unhappily this fauna (which has been recollected since 1961) is poorly diversified and consists of *Plectotyrella chauveli* Havlíček, *Hirnantia* aff. *sagitifera* (M'Coy), *Lingulella* sp., *Pseudobolus* sp., *Conchilolites* sp. and a homalonotid pygidium. The age of this member is uppermost Ashgill (Destombes 1971; Legrand 1974, 1985a, b). Above this the Oued Ali formation is found, whose base is characterized by a ferruginous sandstone with ferruginous nodules and then a bed of sandstone; there follows some varicoloured shales and coarse shaly sandstones with *C. (Climacograptus)* sp., and the member ends with black shales with *C. (Climacograptus)* aff. *rectangularis* M'Coy, *Orthograptus* aff. *mutabilis* Elles & Wood, ?*P. (Metaclimacograptus) phrygius* Törnquist, and *Rastrites* sp., indicating a Middle Llandovery age.

Although this section is only interesting from a local point of view for the definition of the Ordovician–Silurian boundary, it has the wider advantage of showing that the glacial or periglacial environment ended just before the end of the Ashgill.

Conclusions

The Algerian Sahara is surprisingly important in increasing our knowledge of the Ordovician–Silurian boundary period. Studies in eastern Tassili-n-Ajjer show, in an almost continuous section through coastal sediments, the nature of the endemic faunal succession, which, however, has some affinities with southern Siberia. A palaeogeography can be drawn showing the area more or less neighbouring the South Pole, and the observations in the Ougarta Range strongly suggest the almost complete melting of the Upper Ordovician continental ice sheet before the Silurian transgression. This leads us to reconsider the importance of the melting in the mechanism of the transgression (Legrand 1985).

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